

Opportunities and Challenges of Software Customization

Michaela Weiss and Franz Schweiggert

Institute of Applied Information Processing, University of Ulm, D-89069 Ulm, Germany

Email: {michaela.weiss, franz.schweiggert}@uni-ulm.de

Abstract— Customization is a megatrend in today's economy and enables customers to buy products that meet their needs. However, customization offers many more advantages. Thus, a wide range of studies has attempted to analyze customization. Unfortunately, these studies are either limited to physical products or a particular effect of customization. Moreover, there is no comparison of physical products and software. We close this gap by merging the results of existing studies. This comprehensive overview on the advantages of software customization in the Business to Consumer (B2C) area helps to explain the megatrend. Additionally, we highlight challenges that should be addressed by future research. Our results show that software customization is beneficial for customers and companies in numerous ways. Due to its characteristics, the immaterial product software is highly suitable for customization. However, our analysis highlights the great need for future research to facilitate software customization.

Index Terms—Software Customization, Tailoring, User-Centered Design, Human Computer Interaction

I. INTRODUCTION AND RELATED WORK

Customization is a megatrend in the current experience economy and a hallmark of today's interactive media devices [1]. Since the introduction of the business strategy Mass Customization (MC) by Stanley Davis in 1987 [2], customized products have found their way into almost every business sector. As a result of technological progress, customers can now buy clothes, cars, jewellery, electronic articles, etc. that meet their individual needs.

In the software sector, customization is used to adapt software to individual requirements, too. Back in 1999, Pine [3] predicted that customization would be necessary to sell future software.

There are various methods of customizing software. The DUFs software customization classification [4] helps to categorize them by focusing on the starting point of the adaptation. The classification distinguishes design adaptations, usability adaptations, functionality adaptations and adaptations of services and communication. Design adaptations are limited to customization options that adapt the appearance of the Graphical User Interface (GUI) according to individual preferences. Usability adaptations help to fulfill individual tasks in a more effective, efficient, and task-satisfying manner by considering individual user characteristics. Functionality adaptations try to improve the match between the multitude of available features and the ones that are needed by a specific user to perform his/her

tasks. In contrast, adaptations of services and communication customize auxiliary services rather than the software product itself. Adaptations that result in customized communication between the software and the user (e.g. individual greetings or messages) are also assigned to this category.

All these adaptations could be realized by applying different customization strategies. *Adaptable customization* enables the users to adapt the software on their own. In contrast, *adaptive customization* is based on the observation of software usage. The results are used by the software itself to make automatic adaptations. This technique is also used for recommendations in the World Wide Web. Brusilovsky [5] provided a comprehensive survey of adaptive hypermedia research. The third adaptation strategy is the *mixed initiative*, which combines aspects of adaptable and adaptive strategies. Here the software automatically analyzes software usage. Afterwards, it gives advice on adaptations that could improve the individual task completion. If the user agrees in these adaptations, they are made adaptively.

Much research has been carried out to compare these customization strategies. For example, Findlater and McGrenere conducted a study in 2004 [6] to identify best practice for designing menus. They found that, out of a choice of static, adaptable, and adaptive menus, the majority of subjects preferred adaptable customization. Adaptable menus were also ranked first for perceived efficiency – even though the data did not always validate these feelings. In spite of the general preference for adaptable solutions, several subjects strongly preferred the adaptive menus. Thus, the authors highlighted that mixed initiatives could help to cope with these differences in user preferences. Mixed initiatives leave the users in control but encourage them to use customization. Additionally, this strategy minimizes cognitive load as well as adaptation time.

Moreover, many studies have analyzed different ways of implementing a customization strategy. Thus, Gajos et al. [7] as well as Findlater and Gajos [8] evaluated several ways of integrating adaptive customization. These studies documented that users prefer customization that only affects a spatially delimited area rather than customization that changes the whole GUI or menu.

Additionally, prototypes have been implemented to integrate customization options into standard software. For instance, *Flexel* [9] and *LookOut* [10] – customizable versions of Microsoft Excel and Outlook, respectively – have been developed. They confirmed the applicability of customization in everyday software.

Less work has been done in relation to non-technical fundamental issues of software customization. Back in 1991, Mackay [11] tried to find out the triggers and barriers of software customization. The triggers she identified were the wish to reuse functionalities, to adjust versions according to earlier ones, as well as to stop annoying behaviour. In contrast to that, the time needed for making adaptations and a lack of knowledge seemed to inhibit usage of software customization. Page et al. [12] confirmed these results in their study on the usage of a word processor. However, they highlighted that almost every subject used some kind of software customization. This positive response towards offering customization stresses the importance of software customization.

All these studies dealt with a particular aspect of software customization and, in this context, highlighted some advantages and challenges of software customization. However, to our knowledge, there is unfortunately no study that takes a comprehensive look at software customization. Moreover, most studies are limited to technical aspects and do not analyze advantages and challenges from an economic point of view.

In contrast to that, there are various studies on the economic aspects of customization in the non-software area. Piller and Müller [13] gave a tabular overview. Since most of these studies are limited to a particular product category, we made and published a comprehensive analysis [14] which collated the results. This analysis brought together the multiple ways customization affects customers in the non-software area. Moreover it showed how these effects enhance or otherwise challenge companies. Additionally, we presented the *Customization Potential Chart* (CPC), a management tool to evaluate a company's customization potential.

Based on this study, we developed and present an overall analysis of software customization opportunities and challenges in the *Business to Consumer* (B2C) area. Since economic advantages only arise in the interaction with the customers, we focus on the customers' view of software customization and draw the conclusions for the company. Even though the *homo oeconomicus* is the most important concept to explain human behaviour, people do not always act on a purely rational basis. They are also influenced by feelings and emotions. Thus, we take a closer look at soft facts, too. By doing so, we develop a comprehensive overview on the multiple effects of software customization on customers. These effects, in turn, affect a company's competitive position. Our overview helps companies to get a general idea of the opportunities and challenges of software customization. Consequently, it serves as a basis for deciding on whether to become part of this trend.

Additionally, there is no in-depth research to date that compares the competitive advantages of customized physical products and customized software. Our contribution is to close this gap, too. Even though our research highlights the overwhelming potential of software for customization, we shall identify areas of concern and indicate valuable topics for future research.

In the following, Section 2 gives an overview of the manifold advantages of software customization by referring to previous studies. This survey helps to gain a clearer understanding of the various impacts of software customization and explains the megatrend in the B2C area. Additionally, the section highlights its challenges. This analysis provides a solid background for Section 3, which contrasts the customization potential of physical products and software by using a management tool. Section 4 critically examines the software customization potential and identifies valuable topics for future research. Finally, Section 5 concludes.

II. SOFTWARE CUSTOMIZATION OPPORTUNITIES AND CHALLENGES

Many years of research have shown the multiple effects of software customization on customers and companies. This section gives a comprehensive overview of the opportunities and challenges of the megatrend by consolidating existing studies and drawing conclusions.

A. Heterogeneous Needs

Previous research (e.g., [15], [16]) clearly showed that customer needs and skills greatly differ with regard to the product "software". Today's software offers an overwhelming range of features to cope with this heterogeneity. Researchers (e.g. [17], [18]) agree that no software package or interface could satisfy all users. Studies [19], [20] showed that users often only use a small part of the available features. Thus, even though all features can be reasonable from a developer's point of view, they might not be reasonable or useful for a specific user [21]. McGrenere and Moore [19] referred to the multitude of features as *bloat* and distinguished *objective* and *subjective bloat*. Objective bloat identifies functionalities that are neither wanted nor needed by any user and should be avoided. Subjective bloat sums up functionalities that are not needed by a single user and could be reduced with the help of customization.

As Mintzberg [22] stated, customization is the limit case of segmentation – each segment consist of only one customer. Hence, software customization adapts the software characteristics to individual user requirements. It eases the burden of unneeded functionalities, compromises, and GUI complexity. Additionally, software customization could cope with changing needs and skills. Due to the integration of adaptation options, which could also be used to adapt the software according to cultural specificities, customization facilitates global selling.

However, by ignoring real customer needs, particular customization options could also increase the bloat. Moreover, it might not be beneficial for companies to offer all customization options that would be useful for their users. Consequently, it is of crucial importance to offer *virtuous variety*. This is according to Oliver et al. [23] the amount of customization options that creates value for both, customer and company. Thus, software companies have to evaluate

first of all which customization options create value for their customers. Moreover, they have to continuously check whether these options are used in practice.

Customization could also be used to enable accessibility for users with permanent or temporary impairments. For instance, back in 1998, Trewin and Pain [24] developed a model of keyboard configuration requirements, which analyzed individual keyboard usage and made recommendations for improving the configuration. This system belongs to the category of mixed initiative customization. In contrast to that, the *Dynamic Keyboard* system of Trewin [25] automatically adapted the keyboard configuration in accordance with the usage observed and the problems encountered. Such customization options could also be integrated in standard software. By making regular software accessible, software companies could help the inclusion of people with disabilities in society and the workplace. Moreover, people with temporary impairments could carry on using familiar software. From a company's point of view, making software accessible to new customer groups could increase the market share.

In order to realistically estimate a company's customization potential, software companies that decide to participate in customization should first of all evaluate the heterogeneity of their customers' needs. There are significant differences between the application areas. Moreover, the companies need to analyze how enhancing accessibility could be used to increase the market share, keeping in mind their specific market situation.

B. Buyer Power and Individual Fulfillment

According to Koeppl [26], standard software can no longer meet sophisticated user needs. By making software unique, customization could solve this problem. In 2008, a study by Tractinsky and Zmuri [16] illustrated the three dimensions of skins – aesthetics, usability and symbolism. This empiricism proved the symbolic character of the GUI. Thus, the GUI could be adapted to represent the user's identity outwards.

However, software customization has internal effects, too. In terms of adaptable customization, these effects are particularly large. This is because the user can control the adaptations, which enables individual fulfillment. However, from a customer's point of view, adaptable customization increases cognitive load and takes up valuable time. Oppermann and Simm [27] pointed out that not only the adaptation process is exhausting and time-consuming, but also the process to learn how to customize as well as to memorize the adaptations made. By enhancing the amount of adaptations, the burden and complexity increase [28], [29], [30]. However, Franke and Schreier [31] empirically proved that strain could even increase the value of customized products. This is because customers use the success of the self-design process for their cost-benefit analysis. If the preference fit of the end product is high, participation will be well rewarded. In contrast, if the end product does not meet customer needs, the participation is

perceived as negative strain and further reduces the value of the improperly customized product. Thus, it is very important to enable customization that results in a product that meets customer needs.

However, it is not enough to offer customization options that facilitate optimum end products; these options need to be designed in such an accessible way that each single customer can use them. Consequently, the customization toolkit is vital and software developers should design it carefully. This was also the conclusion of Franke and von Hippel [15], who conducted a study on the customization of Apache security software. Moreover, recommender systems could help to decrease the complexity and relieve the customers from completely autonomous adaptations.

In contrast to adaptable customization, adaptive customization does not burden any customer. Nevertheless, it results in a loss of control, individual efficacy, and predictability [32]. Thus, the software – as it is already a mystery for many users [33] – becomes even more mysterious. Software companies could try to cope with this aspect by increasing the transparency of adaptive changes.

The different customization strategies enable software companies to customize the customization. Hence, this helps to fulfill customer needs fully and completely – not only with regard to the product but also with regard to the customization procedure. Finally, the skills, experience, and preferences as well as the tasks and involvement decide on the usage of adaptable customization and the attitude toward adaptive customization [27], [34]. As a result, software developers should give users the power to select the customization strategy, but encourage them to use customization. This could be done by stating the advantages and assisting in the adaptations.

However, before deciding on the correct ways of implementing customization options, software companies need to analyze their customers' reasons for owning unique software as well as their ability to use customization. At an early stage, companies also need to evaluate the software specific potential to offer customization options that result in a satisfying end-product.

C. Satisfaction and User Experience

Software customization could also improve intuitiveness. For this reason, the suitability for individualization is a metric for the operability named in ISO/IEC TR 9126-2 [35]. Bunt et al. [36] showed that making software more intuitive could also speed up the visual search time and the mouse pointing time. Both aspects, in turn, affect performance. Therefore, customization could improve efficiency. According to ISO9241 Part 11 [37], this increases usability. Good usability results in customer satisfaction because users can reach their goals in an efficient and effortless manner [16]. These interrelationships show the positive transitive dependency of customization and customer satisfaction. A study by Franke and von Hippel [15] empirically validated the fact that users who customize their software are more satisfied than users of non-customized software.

Furthermore, a study by Oppermann and Simm [27] proved the potential of customization to reduce cognitive stress and facilitate software usage. Thus, software customization could improve working conditions and ensure optimum development of individual potential.

Besides the aspects mentioned earlier, software customization has further psychological benefits. These benefits are most significant in terms of adaptable customization. The users get the feeling of owning unique software which meets their individual needs. Moreover, they are able to change the software on their own. This strengthens the connection between the user and the software, improves the sense of identity and makes the user proud of his/her authorship. According to Laurel [38], the means to act also result in an improved user experience. Adaptable options encourage play and exploration. Thus, Marathe [39] highlighted that customization stimulates everyday creativity.

Studies have documented that, from a customer's point of view, software customization is worth the effort [36] and results in software that is perceived to be qualitatively superior [40]. Hence, software customization increases the users' benefits.

From a company's point of view, customization helps to enhance customer satisfaction and improve the standing of the product and company. These aspects are essential for software usage. Thus, customization could help to make software successful.

In general, improving customer satisfaction is beneficial for every software company. However, the actual importance of a sense of identity and user experience depends on the field of application. For example, in the software game sector these aspects are of crucial importance. Due to the sector-related differences, every software company needs to individually rate these soft facts. The frequency of software usage plays a central role and needs to be evaluated, too.

D. Implementation Costs and Complexity

A study by Åhlström and Westbrook [41] indicated that most negatives companies associate with customization relate to increasing costs. This is also true in terms of software customization. The integration of customization options has huge effects on the software and creates large up-front costs. Thus, it is a given that the implementation of software customization takes a long time and costs a lot of money. However, even though the developers need to implement customization options, the customization of software has far less impact on the production process and the delivery than the customization of physical goods. Moreover, there are advantages concerning the information delivery. We will refer to these aspects in much more detail in Section 3.

Even though software customization should reduce the individual feature variety, companies need to make sure that all features are available. If users cannot find needed features, they get the feeling the software cannot fulfill their requirements. Thus, GUI adaptations that are not implemented optimally could drive customers away. Therefore, when listing requirements for adaptive interfaces, Billsus et al. [42] advised

against tunnel vision.

The increasing complexity in testing, maintenance and after-sales remains a huge challenge in software customization, too. Thus, many software customizers use Software Product Lines to handle software customization (see e.g., [43], [44]).

To summarize, successfully implementing software customization highly depends on the financial power as well as on existing technological and human resources. Consequently, companies should honestly check their resources before starting to implement customization.

E. Competitive Conditions and Willingness to Pay

According to Franke and von Hippel [15], the software sector faces increasing competitive pressure. Since several companies offer software to process one and the same task, this competitiveness results in price competition. As Parent et al. [45] stated, if a customer perceives that there are no or only few substitutes, there is an increased *Willingness to Pay* (WTP).

Customization helps to differentiate from the competitors and – as Mintzberg [22] said – drives a wedge between a company and its competitors. Thus, the uniqueness of customized products enhances the WTP and protects earnings. Franke and von Hippel [15], e.g., empirically documented this increase of the WTP for a customized version of Apache security software.

However, offering customization does not always help companies to escape from competitive pressure. Marathe and Sundar [1] highlighted that almost every interface is customizable today. For this reason, software companies sometimes simply have to offer customization to remain competitive.

Software companies could include functionalities, closely linked to customization, to implement a pay-per-use initiative. From a customer's point of view, this price customization closes the gap between functionalities used and price paid. This could help to win customers who were previously concerned about the high price of the full version. From a company's point of view, this increases market share.

Thus, every company needs to evaluate whether customization could be voluntarily used to gain competitive advantages, or whether offering customization is absolutely necessary to keep up with its competitors. By analyzing the competitive situation and the competitors' portfolios, the need to participate in this megatrend becomes visible.

F. Economies of Customization

In addition to the higher WTP, there are additional economic advantages of customization. Costs could be reduced by a decrease in stock levels and integration of the customers. Piller and Müller [13] called this phenomenon the *Economies of Customization*.

Even though the effects of decreased stock levels have only minor impact in the software area, the possibilities of customer integration are quite large. By offering adaptable customization options the customers could easily participate

in the value-added chain. The process of transferring activities that a company would normally perform itself to a loosely connected community, e.g. its customers, is called *crowd-sourcing* [45].

According to Prahalad and Ramaswamy [46], customers are more than ever willing to participate. However, they pointed out that users differ in their preferred level of involvement. Adaptable customization or mixed initiatives give each user the power to decide on their degree of participation. Active participation in Open Source initiatives as well as in the willingness to test beta versions show that many people take pleasure in participating [47]. For instance, more than 650,000 users tested a beta version of Microsoft's Windows 2000 and helped to improve the operating system by giving advice and reporting their experiences [46]. Parent et al. [45] called this Willingness to Participate "the new WTP". Findings of customer participation could also be used for continuous improvement and Open Innovation. Thus, software features, software appearance and customization options could be adjusted to demand.

Before implementing any customization option, software companies should determine if and to what extent they want to enable customer participation. Moreover, they need to decide on the further processing of knowledge, which is generated through customer participation. This helps to design proper methods of customer co-design.

G. Learning Relationship

Due to the accumulation of knowledge, customization could build up a very strong connection between company and customer. Over time, the company gets more and more sticky information on each user. This knowledge building is called *learning relationship*.

A study by Åhlström and Westbrook [41] showed that companies consider this continuous collection of information to be one of the key assets of customization. Researchers (e.g. [48], [49], [50]) agree about the positive effect of customer commitment on switching costs. Riemer and Totz [51] illustrated the three categories of switching costs. *Direct costs* occur because of the search for a new supplier and the building of the new relationship. *Opportunity costs* are caused by the uncertainty of the new relationship. Finally, *sunk costs* are irreversible customer investments. Thus, learning relationships, which are strongly linked with customization, could help to retain customers.

Reichheld and Sasser [14] empirically analyzed the interrelation between defection rate and customer value. With regard to the software sector, they found out that a decrease in defection rate by 5% increases customer value by 35%. Sievänen [52] assigned this aspect to the effects of customization on the sales department. From a marketing point of view, customization also helps to avoid inefficient advertising [50].

In terms of the customization effects on the research and development department, Sievänen [52] suggested that learning relationships give insights into customer requirements. This knowledge could be used to improve the

production process and extend customization options.

Customization also effects the production department. It increases the sales and, in turn, increases the production volumes. On the one hand, this effect is based on strengthening customer numbers by offering products that meet customer needs. On the other hand, learning relationships facilitate cross and up-selling. These techniques enhance the Customer Lifetime Value.

However, in contrast to the customization of physical products, the customers do not directly tell the company their needs. The adaptations are done by the software itself. This takes place rather on the basis of user instructions or by observing individual usage. With regard to privacy concerns, data from usage observation in particular is very critical. In her critical evaluation of configuration agents, Trewin [17] highlighted that user modeling could contain very sensitive physical, sensory, cognitive and linguistic data. Consequently, data protection and enhancement of transparency is a key concern and should always be considered by software companies.

According to Westin [53], privacy is an individual's right to determine on when, how and to what extent private information is communicated to others. Thus, everybody needs to find a balance of his/her need for privacy and the desire for self-expression. By enabling users to decide on their individual level of customization, software companies could cope with these needs.

Especially software companies who suffer from defection because of the high competitive pressure in their line of business could benefit from implementing customization. Furthermore, software companies that plan to implement customization should evaluate their portfolio's potential for cross and up-selling.

III. COMPARING PHYSICAL PRODUCTS AND SOFTWARE

The previous section analyzed the advantages of software customization in the B2C area in detail. Many of these advantages also apply to the non-software area. Here a CPC [54] could be used to evaluate a product's customization potential.

The CPC analyzes the product's customization potential from many different angles and illustrates the overall customization potential. To rate a product's customization potential, the analyst needs to answer several questions by using a scale from *low* to *high*. Thus, for example, the analyst evaluates the product's potential to express individuality, the competitiveness of the market, the heterogeneity of customer needs and the company's technical and human resources.

By connecting the answers, a profile line for the product's customization potential becomes visible. If many answers achieve high values, the product has a large customization potential. In contrast to that, low values indicate a low customization potential. Moreover, the CPC illustrates that the different valuation issues differ in their stability. Some of the aspects are determined by the market or product group.

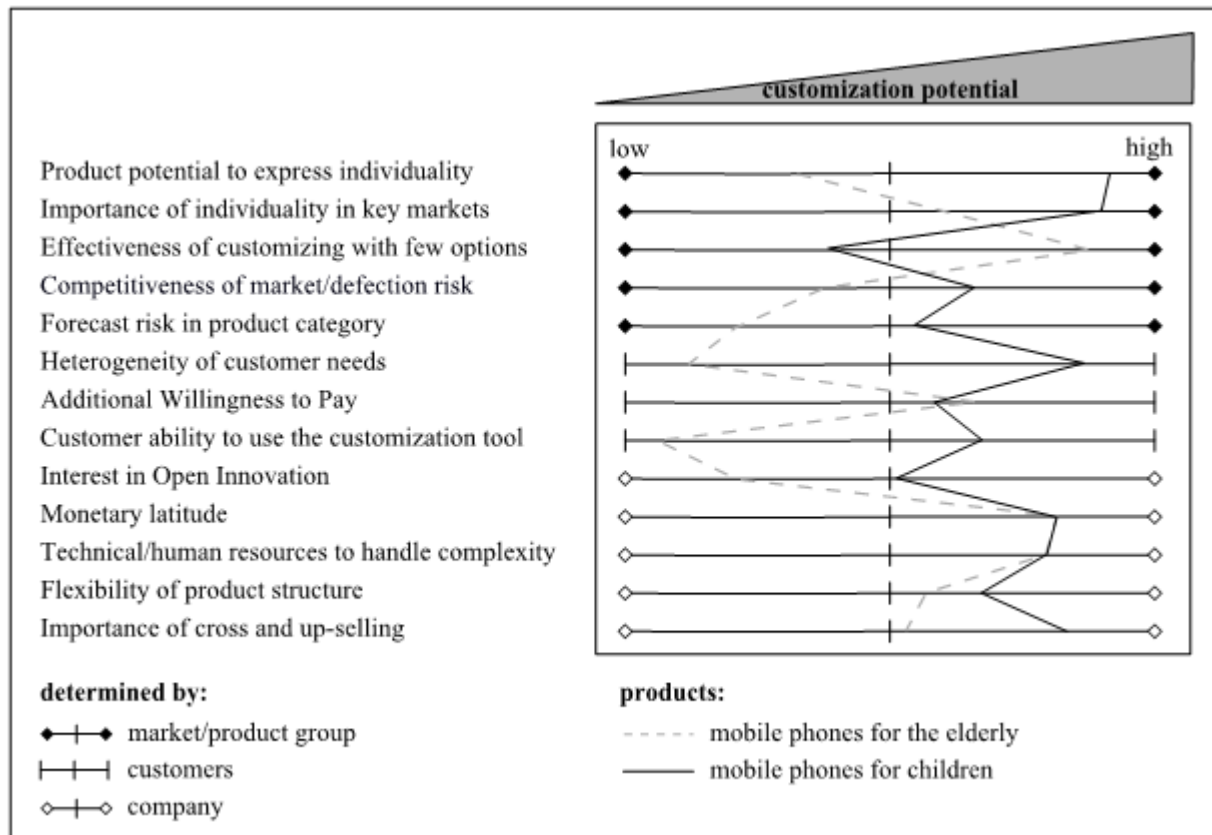


Figure 1. Example of a Customization Potential Chart which compares mobile phones for the elderly and mobile phones for children [54].

Thus, they are unchangeable and constitute weak points. Others aspects are determined by the customers. Such aspects could sometimes be influenced by the company. There are also aspects that are determined by the company itself. Aspects that limit a product's customization potential but are determined by the company could be changed. Consequently, a CPC not only illustrates a product's current customization potential but highlights individual room for improvement.

CPCs could also contain several products and help companies to compare the potential of their products. Moreover, companies could use a CPC for benchmarking by comparing their products with those of competitors.

Fig. 1 shows an example of a CPC which compares two products of the same company, mobile phones for the elderly and mobile phones for children. It highlights the higher potential of integrating customization options into mobile phones for children.

Even though there are similarities in the customization of physical products and software, the previous section already indicated that there are important differences, too. Thus, we used the categories of the CPC to analyze these differences. In the following, each category of the CPC is used to compare the customization potential of physical products and software.

A. Product Potential to Express Individuality

In many product categories, the ability to express one's individuality with the help of the product is an important soft fact which determines consumption.

Generally, only things that are visible to others can help communicate one's individuality outwards. Thus, the immateriality of software should result in limited possibilities of self-expression.

However, the potential to express individuality is overwhelming with regard to software games and virtual reality.

Nevertheless, the study by Tractinsky and Zmiri [16] proved the symbolic character of the GUI. Consequently, customization that adapts the GUI of standard software could also be used to express one's individuality. The incisive use of existing customization options, which is proven with the help of several studies (e.g. [55]), supports this conclusion.

However, the software-specific potential to express individuality depends on the type of software, just like the potential of physical product depends on the product category. Thus, no general conclusion can be drawn.

B. Importance of Individuality in Key Markets

In the software sector as well as in the non-software sector, the importance of individuality in the key markets determines the success of customization implementation. However, in our globalized economy, companies often supply several markets.

In the software area, the implementation of customization options for a particular key market is quite flexible. The core product could be prepared for customization. Companies could then use Internationalization and Localization to adapt customization options according to each key market.

Internationalization isolates culture-specific content [56]. In this context, customization options could be capsulated, too. Afterwards, Localization adapts these isolated aspects according to the key market [56]. Here the customizability could also be enabled or disabled to meet the cultural specificities of the key market.

In contrast to that, customization is generally more greatly integrated in the production process of a physical product. Thus, it is more difficult to enable or disable all or any of the customization options in a single market.

C. Effectiveness of Customization with Few Options

Integrating customization options is costly and increases complexity. Thus, from a company's point of view, it is important to limit the number of customization options or the amount of necessary product adaptations. At the same time, the company needs to enable effective customization.

Since a mere adaptation of the GUI makes a customer perceive that the whole software is customized, effective customization could already be achieved by implementing only a few options. Even though the core product is not adapted at all, the customized software appearance gives the user the feeling of owning unique software. In the non-software area customization generally strongly affects the product and its production.

Moreover, in the non-software sector, the costs of returning customized goods are a critical factor. Due to the immaterialness of software and the adaptive customization, these risks do not exist in the software sector.

These aspects are important advantages of software customization.

D. Competitiveness of Market / Defection Risk

The competitiveness of the market has a major influence on the product's customization potential. The stiffer the competition a company faces, the higher the need to distinguish itself from its competitors. With the help of customization, companies could achieve a unique selling proposition. Hence, customization helps companies to retain customers and reduce the defection risk.

The software sector is a highly competitive market. Thus, the implementation of customization options is very beneficial and increases the potential of software for customization.

However, the conditions of competition are appreciably different among the various lines of business. Thus, a general comparison of software and physical products cannot be made.

E. Forecast Risk in Product Category

The made-to-order principle, which is closely linked to customization, helps to reduce forecast risks. Consequently, companies that suffer from this risk in particular could benefit from implementing customization.

In the software sector the forecast risks, which result in unfavorable storage, are quite low. With regard to this aspect, the customization potential of physical products is undoubtedly higher.

However, from a customer's point of view, customization has forecast risks, too. The company is reliant on information from the customer. However, sometimes the customers' knowledge of their own needs is limited. Thus, Möslin et al. [57] pointed out that the information, which is a critical success factor, could be incorrect. Such incorrect information results in end-products that do not meet customer needs. In contrast to the customization of physical goods, software customization is quite safe. This is because of the re-adaptability of software. The user could simply test different customization settings to find the preferred one or the software analyzes the usage and automatically adjusts the optimum setting. Furthermore, customers do not need to wait for the "production" and delivery of their software. All these hidden transaction costs – as they are called by Berger and Piller [58] – which exist with physical goods do not occur because of the characteristics of software. Here, software customization has clear advantages.

F. Heterogeneity of Customer Needs

If customer needs diverge, it is difficult or even impossible to meet individual needs with the help of a standard product. Customization could solve this problem.

With regard to software, the heterogeneity in needs is huge. In our society, which is characterized by the fast pace of modern life, requirements quickly change. While these considerations apply to most product categories, they are particularly true in terms of electronic articles and software. Thus, the heterogeneity of customer needs as well as the limited task stability increases the customization potential of software.

G. Additional Willingness to Pay

From a company's point of view, the additional WTP is a huge advantage of customization. However, a customer's WTP is based on the product category. Thus, the additional WTP in the appropriate product category determines customization potential; the greater the additional WTP for a customized product, the higher the customization potential.

Looking at the additional WTP, customer opinions greatly differ with regard to software. On the one hand, many people spend a considerable amount of money on software. On the other hand, there is a strong community of free open source software. Consequently, it is quite difficult to make general assumptions. Each company needs to evaluate the additional WTP, which could be realized by offering customizable software.

In principle in the B2C area, customizable physical products should have a larger potential than customizable software. However, the study by Franke and van Hippel [15] empirically validated that software customization increases the WTP.

H. Customer Ability to Use the Customization Tool

Every company that enables customization needs to make these options accessible for its heterogeneous customers. Otherwise, the customization options will lose their effectiveness. Consequently, every company needs to

carefully design its configuration tools.

However, by using mixed initiatives or adaptive customization, software companies could easily support their customers in using customization and ease the burden of time-consuming adaptations. Thus, they could ensure that customization takes place and in an optimum way.

Since customization adaptations are mainly done by the software itself or in the interaction with the software, there is no need for an external customization configurator. This lack of an additional tool, which is absolutely necessary to configure customized physical products, could further reduce the complexity of software customization.

In contrast to that, in the non-software area it is often very difficult to implement a customization procedure that copes with different customer abilities.

I. Interest in Open Innovation

The CPC indicates that a company's interest in Open Innovation affects the customization potential. In particular, companies that greatly rely on the pooling of knowledge benefit from implementing customization. This is because customization provides the company with additional information on best practices for product configurations. Thus, customers jointly improve the product design, a task which was formerly performed by the company itself.

Many software companies rely on Open Innovation. The widespread use of Open Innovation in the software sector increases the customization potential of software. However, the usage of Open Innovation in the non-software sector is gaining more and more importance.

J. Monetary Latitude / Technical and Human Resources

The monetary latitude as well as the technical and human resources are very important when handling the costs and complexity of customization. These preconditions for successful participation in the megatrend need to be evaluated on an individual basis.

However, with regard to software, these costs are comparatively low because of the minor effects on the production process. There is no need to "produce" customized software; it can be automatically configured [59]. This aspect lowers the costs of selling customized software. Moreover, the feasibility of software to adapt itself facilitates the critical need for private information on customer requirements.

In contrast, a direct intervention in the production process and an upstream information exchange is necessary to produce customized physical goods.

As a consequence of its characteristics, software customization places less strain on a company's resources.

K. Flexibility of Product Structure

According to Ponn et al. [60], customization requires flexible structures. The more flexible the product structure, the easier the adaptation of the product according to individual customer needs. Thus, flexible structures help companies to implement customization.

In contrast to physical products, software initially brings

along flexible structures due to its digital content and modular design. This makes software extremely suitable for customization.

Besides the advantages of offering customized products, software offers flexibility in making these adaptations. Hence, customization can be customized, too. This enables an even greater accuracy in meeting customer needs and enhances the customization potential of software.

L. Importance of Cross and Up-Selling

In many lines of business, product lifecycles are very short. From a company's point of view, this results in pressure to ensure customer retention and enhance the Customer Lifetime Value. This can be done with the help of cross and up-selling. Customization facilitates cross and up-selling by providing the company with information on customer requirements.

With regard to software, developments are very rapid and product lifecycles quite short. Thus, cross and up-selling could be used to secure profitability.

However, software companies generally do not use cross and up-selling to the same huge extent as, e.g., insurance companies do.

IV. DISCUSSION AND NEED FOR FUTURE RESEARCH

Comparison of the customization potential of software and physical products revealed that software is highly suitable for customization. From an economic point of view, software has a huge potential for customization, which could be used to create competitive advantages. Thus, in the long term, software companies will not be able to ignore the demand-driven trend of customization.

Even though software seems to be predestined for customization, analysis showed that many challenges exist too. Some of them could be facilitated with the help of further research. In the following, we list several ideas for valuable future research.

A. Studies to Identify Virtuous Variety

Due to technical means, software companies have to face the major challenge of offering virtuous variety. Thus, they need to know which customization options create value for their customers and which ones are useless.

In order to supply software companies with this relevant information, we need large-scale studies on customer perception of software customization. This might include studies, which use and further subdivide the DUFSS software customization classification to evaluate general software customization options. The former study by Weiss and Heidenbluth [55] could be regarded as a starting point for further research.

Even though such studies will not replace company-specific studies based on particular software, they could simplify entry into the field of software customization by giving guidelines.

B. Basic Research into Integrating Adaptable Customization or Mixed Initiatives

Adaptable customization options as well as mixed initiatives are based on customer interaction. Consequently, such customization options are only beneficial, if the users can easily find and use them. From a company's point of view, it is very difficult to implement customization options that are accessible and usable for any one of its heterogeneous users.

Thus, basic research should be conducted to give software companies guidance for an optimum design. Standardized access to customization options might help customers use software customization.

Besides making customization options accessible, further studies could give insights into improving user experience during configuration.

C. Software-Independent Customization Options

A significant part of customization options, which increase accessibility, improve usability or adapt GUI design according to individual preferences could be implemented independent of software. Unfortunately, no methods are available to easily integrate such general options.

Implementing customization frameworks, classes or plug-ins could ease the burden of customization implementation for each individual software company. For example, research may provide methods to automatically use the information of the working system for adaptive customization. Additionally, a customization plug-in enabling adaptation of the GUI appearance according to individual design preferences could be implemented.

D. Frameworks to Handle Complexity

A major challenge of software customization is mastering the complexity. Especially with regard to maintenance and after-sales, the differences in handling and appearance of customized software versions create difficulties. Further research is needed to help software companies cope with the loss of standardization.

This could be done by implementing frameworks that help companies to handle the multitude of customer-specific software versions. These frameworks could also be used by the after-sales department to manage customer enquiries and give version-specific assistance.

V. CONCLUSIONS

By combining existing findings on the advantages of customization, we have provided a comprehensive overview on software customization. This analysis has documented that software customization has various advantages for customers and companies. Consequently this paper has helped to explain the megatrend of software customization in the B2C area.

Today's software offers a confusing feature variety, which is a result of the technical means and the heterogeneity of customer needs. Software customization helps to limit the available functionalities and adapts the range of functions

according to changing tasks. Moreover, software customization could enhance subjective perception by enabling individual fulfillment and enhancing customer satisfaction. This increases the Willingness to Pay and Participate. With the help of learning relationships, the Customer Lifetime Value could be extended and the increasing competitive pressure could be managed. All these positive facts mitigate the implementation investment and costs of complexity.

Even though our analysis has shown that software customization has clear advantages compared with the customization of physical goods, the costs are still a critical factor. To contain costs and promote the spread of software customization, further general research is needed. We have given an overview of important aspects for future research. Thus, we have provided a good basis for improvements. On the one hand, these improvements could help software developers to successfully participate in the megatrend. On the other hand, they could help to supply users with software that really meets their needs.

REFERENCES

- [1] S. Marathe and S. S. Sundar, "What Drives Customization? Control or Identity?" in Proc. of the 2011 Annual Conf. on Human Factors in Computing Systems, 2011, pp. 781–790.
- [2] S.M. Davis, *Future Perfect*. Reading: Addison-Wesley, 1987.
- [3] B. J. Pine II, *Mass Customization: The New Frontier in Business Competition*, Boston: Harvard Business School Press, 1993.
- [4] M. Weiss and N. Heidenbluth, "A Two-Dimensional Overall Software Customization Classification and Visualization," in Proc. of the 2012 Int. Conf. on Software Engineering Research & Practice, 2012, pp. 293–299.
- [5] P. Brusilovsky, "Adaptive Hypermedia," *User Modeling and User-Adapted Interaction*, vol.11, pp. 87–110, 2001.
- [6] L. Findlater and J. McGrenere, "A Comparison of Static, Adaptive, and Adaptable Menus," in Proc. of the SIGCHI Conf. on Human Factors in Computing Systems, 2004, pp. 89–96.
- [7] K. Z. Gajos, M. Czerwinski, D. S. Tan, and D. S. Weld, "Exploring the Design Space for Adaptive Graphical User Interfaces," in Proc. of the Working Conf. on Advanced Visual Interfaces, 2006, pp. 201–208.
- [8] L. Findlater and K. Z. Gajos, "Design Space and Evaluation Challenges of Adaptive Graphical User Interfaces," *AI Magazine*, vol. 30(4), 2009, pp. 68–73.
- [9] C. G. Thomas and M. Krogseter, "An Adaptive Environment for the User Interface of Excel," in Proc. of the 1st Int. Conf. on Intelligent User Interfaces, 1993, pp. 123–130.
- [10] E. Horvitz, "Principles of Mixed-Initiative User Interfaces," in Proc. of the SIGCHI Conf. on Human Factors in Computing Systems, 1999, pp. 159–166.
- [11] W. E. Mackay, "Triggers and Barriers to Customizing Software," in Proc. of the SIGCHI Conf. on Human Factors in Computing Systems, 1991, pp. 153–160.
- [12] S. R. Page, T. J. Johnsgard, U. Albert, and C. D. Allen, "User Customization of a Word Processor," in Proc. of the SIGCHI Conf. on Human Factors in Computing Systems, 1996, pp. 340–346.

- [13] F. T. Piller and M. Müller, "A New Marketing Approach to Mass Customisation," in *Int. J. Computer Integrated Manufacturing*, vol. 17, 2004, pp. 583–593.
- [14] F. F. Reichheld, W. E. Sasser Jr., "Zero Defections: Quality Comes to Services," *Harvard Business Review*, September–October 1990, pp. 105–111.
- [15] N. Franke and E. von Hippel, "Satisfying Heterogeneous User Needs via Innovation Toolkits: The Case of Apache Security Software," *Research Policy*, vol. 32(7), pp. 1199–1215, 2003.
- [16] N. Tractinsky and D. Zmuri, "Exploring Attributes of Skins as Potential Antecedents of Emotion in HCI," in *Aesthetic Computing*, MIT Press, 2008, pp. 405–422.
- [17] S. Trewin, "Configuration Agents, Control and Privacy," in *Proc. on the 2000 Conf. on Universal Usability*, 2000, pp. 9–16.
- [18] N. Zang, M. B. Rosson, and V. Nasser, "Mashups: Who? What? Why?" in *CHI'08 Extended Abstracts on Human Factors in Computing Systems*, 2008, pp. 3171–3176.
- [19] J. McGrenere and G. Moore, "Are We All in the Same Bloat?" in *Proc. of Graphics Interface*, 2000, pp. 187–196.
- [20] A. Bunt and M. Terry, "Opportunities for User Involvement within Interface Personalization," in *Workshop on Intelligence and Interaction*, 2009.
- [21] J. M. Carroll and M. B. Rosson, "Paradox of the Active User," in *Interfacing Thought: Cognitive Aspects of Human-Computer Interaction*, MIT Press, 1987, pp. 80–111.
- [22] H. Mintzberg, "Generic Strategies: Towards a Comprehensive Framework," *Advances in Strategic Management*, vol. 5, 1988, pp. 1–67.
- [23] K. Oliver, L. Moeller, and B. Lakenan, "Smart Customization: Profitable Growth Through Tailored Business Streams," *strategy+business*, vol. 34, 2004, pp. 34–45.
- [24] S. Trewin and H. Pain, "A Model of Keyboard Configuration Requirements," in *Proc. of the third int. ACM Conf. on Assistive Technologies*, 1998, pp. 173–181.
- [25] S. Trewin, "Automating Accessibility: The Dynamic Keyboard," in *Proc. of the 6th Int. ACM SIGACCESS Conf. on Computers and Accessibility*, 2004, pp. 71–78.
- [26] D. Koepfel, "GUIs Just Want to Have Fun," [online] on *Newsstands Now*, Issue 8.1, 2000, Available at: <<http://www.wired.com/wired/archive/8.10/skins.html>> [Accessed 24th of October 2013].
- [27] R. Oppermann and H. Simm, "Adaptability: User-Initiated Individualization," in *Adaptive User Support*, Lawrence Erlbaum Associates, 1994, pp. 14–66.
- [28] J. W. Payne, "Task Complexity and Contingent Processing in Decision Making: An Information Search and Protocol Analysis," *Organizational Behavior and Human Performance*, vol. 16, 1976, pp. 366–387.
- [29] C. Huffman and B. Kahn, "Variety for Sale: Mass Customization or Mass Confusion?" *J. of Retailing*, vol. 74, 1998, pp. 491–513.
- [30] R. Zeleznik, T. Miller, and A. Forsberg, "Pop Through Mouse Button Interactions," in *Proc. of the 14th Annual ACM Symposium on User Interface Software and Technology*, 2001, pp. 195–196.
- [31] N. Franke and M. Schreier, "Why Customers Value Self-Designed Products: The Importance of Process Effort and Enjoyment," *J. of Product Innovation Management*, vol. 27, 2010, pp. 1020–1031.
- [32] U. Manber, A. Patel, and J. Robison, "Experience with Personalization on Yahoo!" *Communications of the ACM*, vol. 43, August 2000, pp. 35–39.
- [33] W. W. Gibbs, *Software Engineering*, M. Dorfman and R. H. Thayer, Eds. Los Alamitos: IEEE Computer Society Press, 1997.
- [34] N. Franke, P. Keinz, and C. J. Steger, "Testing the Value of Customization: When Do Customers Really Prefer Products Tailored to Their Preferences?" *J. of Marketing*, vol. 73(5), 2009, pp. 103–121.
- [35] ISO/IEC TR 9126-2:2003: *Software Engineering – Product Quality – Part 2: External Metrics*. International Organization for Standardization, Geneva, Switzerland.
- [36] A. Bunt, C. Conati, and J. McGrenere, "What Role Can Adaptive Support Play in an Adaptable System?" in *Proc. of the 9th Int. Conf. on Intelligent User Interfaces*, 2004, pp. 117–124.
- [37] ISO 9241-11:1998: *Ergonomic Requirements for Office Work with Visual Display Terminals (VDTs) – Part 11: Guidance on Usability*. International Organization for Standardization, Geneva, Switzerland.
- [38] B. K. Laurel, "Interface as Mimesis," in *User Centered System Design: New Perspectives on Human-Computer Interaction*, L. Erlbaum Associates Inc., 1986, pp. 67–86.
- [39] S. Marathe, "Stimulating Everyday Creativity: Harnessing the Potential of Customizable GUIs," in *Proc. of the 28th of the Int. Conf. Extended Abstracts on Human Factors in Computing Systems*, 2010.
- [40] C. Nass, Y. Moon, B. J. Fogg, B. Reeves, and D. C. Dryer, "Can Computer Personalities Be Human Personalities?" in *Int. J. of Human-Computer Studies*, vol. 43, 1995, pp. 223–239.
- [41] P. Åhlström and R. Westbrook, "Implications of Mass Customization for Operations Management," *Int. J. of Operations & Production Management*, vol. 19(3), 1999, pp. 262–274.
- [42] D. Billsus, C. A. Brunk, C. Evans, B. Gladish, and M. Pazzani, "Adaptive Interfaces for Ubiquitous Web Access," *Communications of the ACM*, vol. 45, May 2002, pp. 34–38.
- [43] J. Bosch, "Maturity and Evolution in Software Product Lines: Approaches, Artifacts, and Organizations," in *Proc. of the Second Int. Conf. on Software Product Lines*, 2002, pp. 257–271.
- [44] K. Pohl, G. Böckle, and F. van der Linden, *Software Product Line Engineering*. New York: Springer, 2005.
- [45] M. Parent, K. Plangger, and A. Bal, "The New WTP: Willingness to Participate," *Business Horizons*, vol. 54, 2011, pp. 219–229.
- [46] C. K. Prahalad and V. Ramaswamy, "Co-Opting Customer Competence," *Harvard Business Review*, vol. 78(1), 2000, pp. 79–87.
- [47] M. Schreier, "The Value Increment of Mass-Customized Products: An Empirical Assessment," *J. of Consumer Behaviour*, vol. 5, 2006, pp. 317–327.
- [48] K. N. Lemon, R. T. Rust, and V. A. Zeithaml, "What Drives Customer Equity?" *Marketing Management*, vol. 10(1), 2001, pp. 20–25.
- [49] A. Gustafsson, M. D. Johnson, and I. Roos, "The Effects of Customer Satisfaction, Relationship Commitment Dimensions, and Triggers on Customer Retention," *J. of Marketing*, vol. 69, 2005, pp. 210–218.
- [50] F. T. Piller, K. Moeslein, and C. M. Stotko, "Does Mass Customization Pay? An Economic Approach to Evaluate Customer Integration," *Production Planning & Control*, vol. 15(4), 2004, pp. 435–444.

- [51] K. Riemer and C. Totz, "The Many Faces of Personalization", in *The Customer Centric Enterprise Advances in Mass Customization and Personalization*, 2003, pp. 35–50.
- [52] M. Sievänen, "What Is Customization?" in *Proc. of the 9th Int. Annual Conf. of European Operations Management Association*, vol. 2, 2002, pp. 1367–1378.
- [53] A. F. Westin, *Privacy and Freedom*, New York: Atheneum, 1967.
- [54] M. Weiss and F. Schweiggert, "Opportunities and Challenges of the Customization Megatrend: A Mangement Tool to Evaluate Customization Potential," in *Proc. of the Int. Conf. on Advanced Research in Business*, 2013, pp. 39–44.
- [55] M. Weiss and N. Heidenbluth, "Future Chances of Software Customization: An Empirical Evaluation," in *Proc. of the Seventh Int. Conf. on Software Engineering Advances*, 2012, pp. 479–485.
- [56] P. Russo and S. Boor, "How "Fluent Is Your Interface? Designing for international users," in *Proc. of the INTERACT '93 and CHI '93 Conf. on Human Factors in Computing Systems*, pp. 342–347, 1993.
- [57] K. Möslin, F. T. Piller, and R. Reichwald, "Information as a Critical Success Factor for Mass Customization or: Why Even a Customized Shoe Does Not Always Fit," in *Proc. of the ASAC-IFSAM Conf.*, 2000.
- [58] C. Berger and F. T. Piller, "Customers as Co-Designers," *IEE Manufacturing Engineer*, August/September 2003, pp. 42–45.
- [59] J. Wind and A. Rangaswamy, "Customerization: The Next Revolution in Mass Customization," *J. of Interactive Marketing*, vol. 15(1), 2001, pp. 13–32.
- [60] J. Ponn, C. Baumberger, and U. Lindemann, "Guidelines for the Development of Individualized Products," in *Proc. of the 8th Int. Design Conf.*, 2004.